



## Using SpaceClaim/TD Direct for Modeling Components with Complex Geometries for the Thermal Desktop-based Advanced Stirling Radioisotope Generator Model

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# OVERVIEW



- INTRO
  - WHAT?, WHY?, BACKGROUND (OF THE AUDIENCE)?
  - PROBLEMS & SOLUTIONS?
  - ASRG
    - BACKGROUND
    - MODELING
- SOFTWARE
  - THERMAL DESKTOP (TD)
  - SPACECLAIM ENGINEER & TD DIRECT “ADD-ON”
- PROCESS OVERVIEW
  - IMPORTING
  - REPAIR & DEFEATURING/SIMPLIFICATION
  - TAGGING
  - MESHING & EXPORTING TO TD
- ASRG-BASED EXAMPLES
- BEST PRACTICES/LESSONS LEARNED
- SUMMARY



- What???
  - The purpose is to give an overview, through the example of modeling the ASRG, of how SpaceClaim/TD Direct might be used in your modeling tasks. If you have walked away with a better sense of what the capabilities are and how one might incorporate into their workflow – then this presentation is a success!
- Why???
  - One of the ‘classic’ problems of FD and FEM modeling is generating the geometry or importing the geometry from different CAD or other analysis packages (e.g. structures) – SpaceClaim/TD Direct is one solution to that problem now available to those of us using Thermal Desktop.
- Background???
  - Do you already use SpaceClaim/TD Direct...or...have you never heard of it?



# INTRO: PROBLEM & SOLUTION



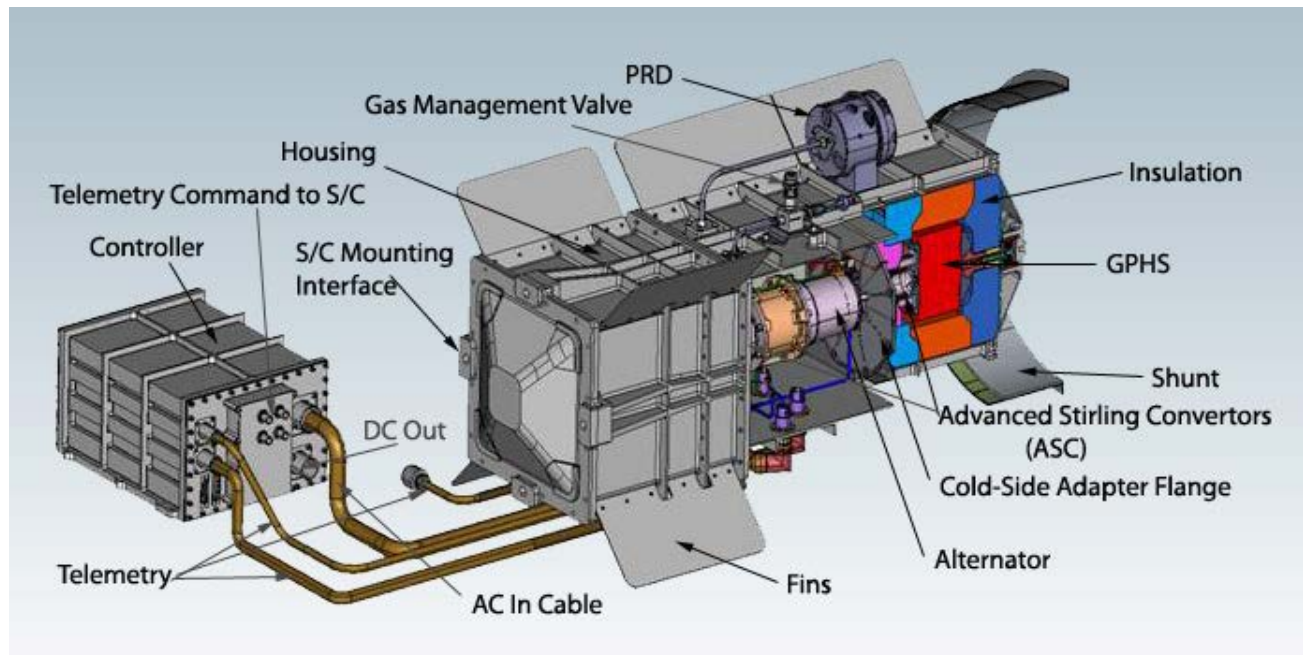
- **PROBLEM:**
  - Maintaining geometric high fidelity of ASRG's complex components to satisfy interests of researches into heat flows and temperature gradients.
  - Thermal Desktop's capabilities for creating & modifying finite element (FE) meshes.
- **SOLUTION:**
  - Using modeling features of SpaceClaim Engineer (SC) for import and defeaturing/simplification of CAD geometries into TD.
  - Use TD Direct (SC add-on) for generating and modifying FE meshes in TD.



# INTRO: ASRG BACKGROUND



- ASRG = Advanced Stirling Radioisotope Generator
- Higher efficiency, higher specific power
- Meet future power needs for multi-mission requirements
- ASRG is dynamic power source (unlike MMRTG)
- Based on Advanced Stirling Convertor (Sunpower, GRC)

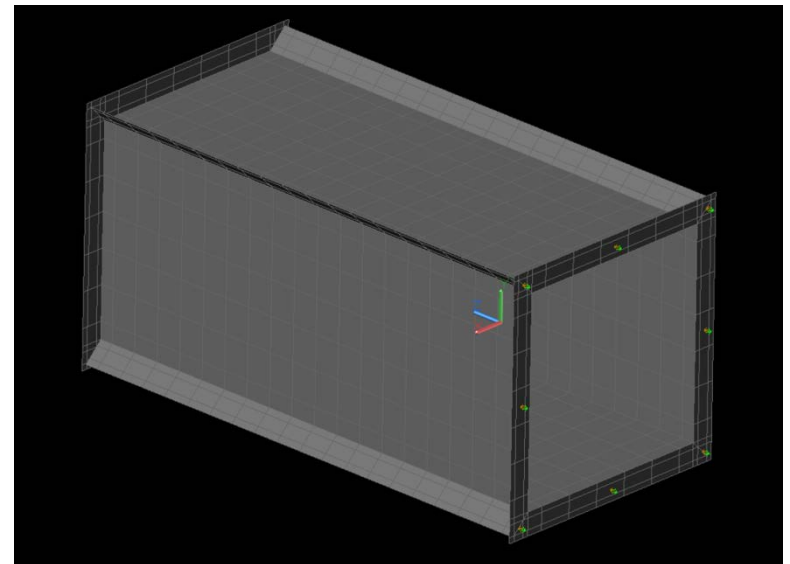
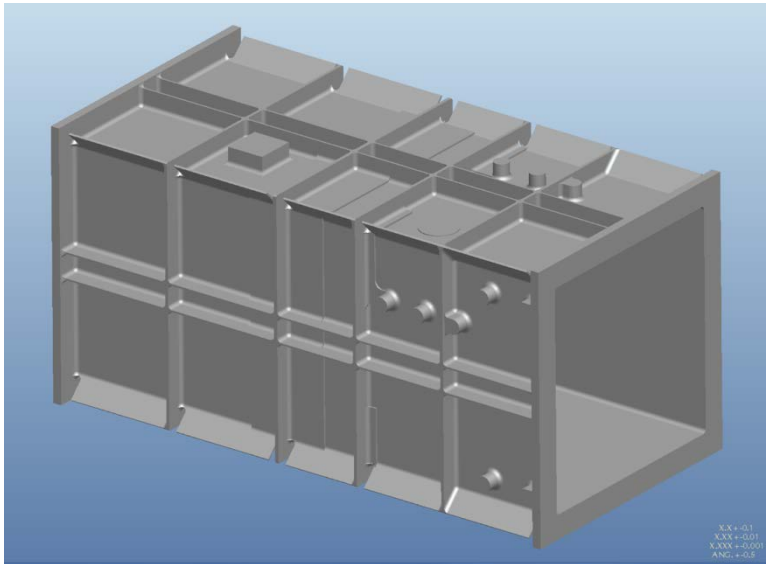




# INTRO: ASRG MODELING



- Thermal Desktop (TD) ASRG model used to predict component temperatures, power output, and provide V&V
- Most components adequately modeled with FD surfaces and solids.



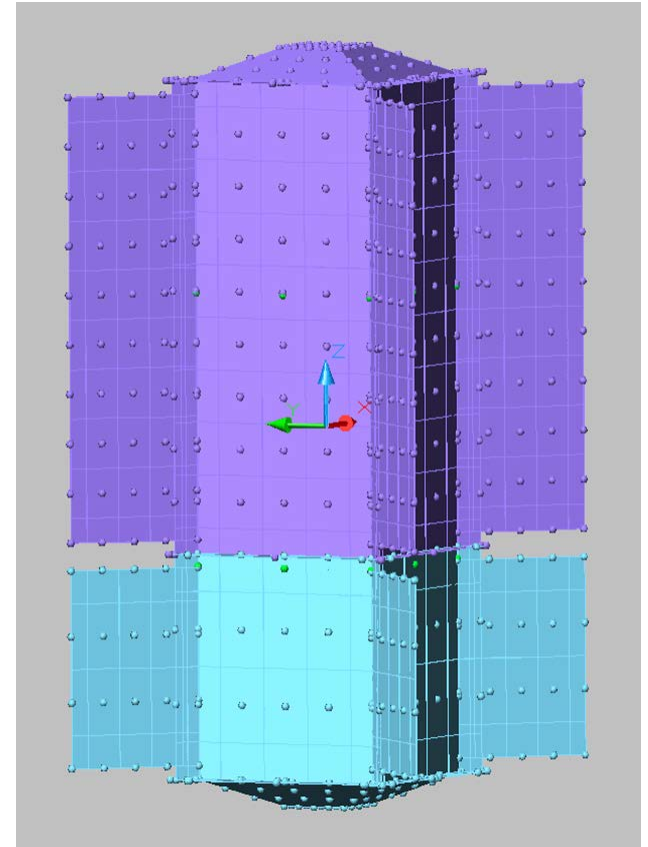
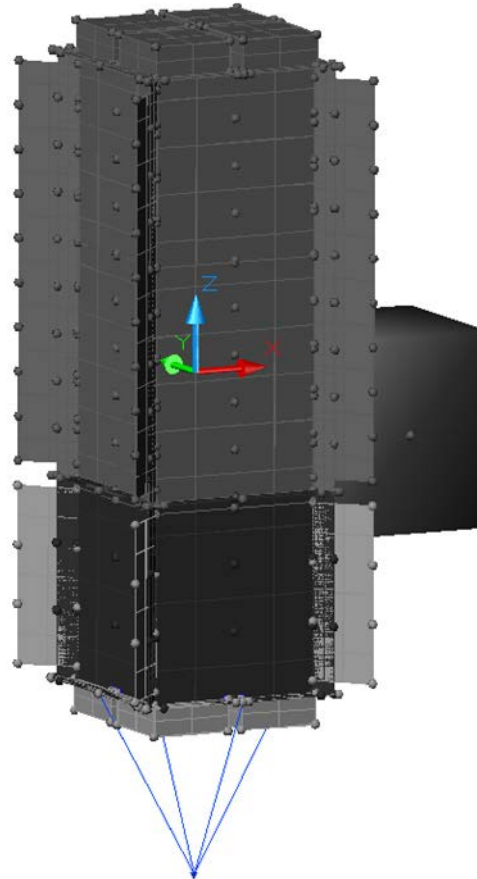




# INTRO: ASRG MODELING



(left) ASRG-EU on test at GRC, (middle) early ASRG-EU TD model, (right) ASRG-F

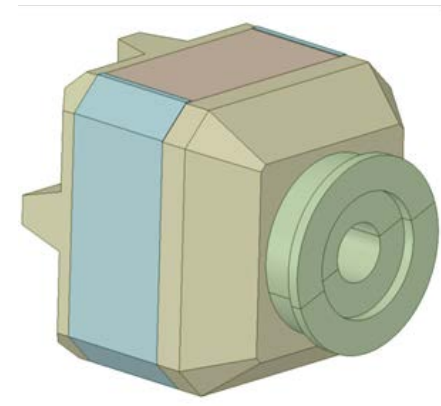
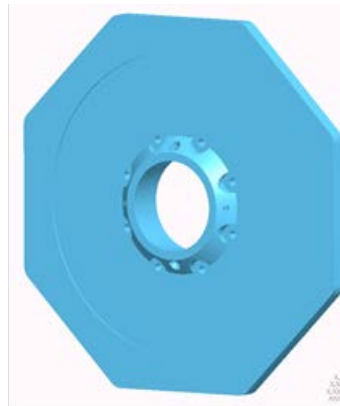
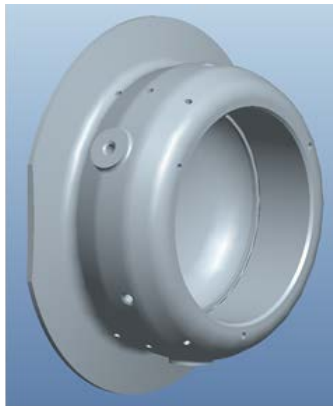




# INTRO: ASRG MODELING



- Researchers interested in fine details of:
  - Heat collector
  - Cold-side Adapter Flange (CSAF)
  - Insulation Block



- Problem:
  - Difficult to maintain geometric high fidelity within TD
- Solution:
  - SpaceClaim / TD Direct





*(For completeness sake...)*

- TD:
  - Broadly used within the NASA and aerospace thermal community
  - GUI for SINDA/FLUINT
  - Runs inside the AutoCAD environment
    - AutoCAD tools can be used to generate geometries – covert to TD
    - TD Finite Difference (FD) nodes, surfaces, solids can be generated
  - Has native FE mesher, TDMesh.
    - Limitations:
      - Meshing assemblies
      - Updating meshes
      - Controlling local mesh features, specifying different element types



- SC is a direct modeling tool
  - Used for import or to natively produce geometries
  - Can read in most major CAD formats (See SC website)
  - TD Direct available as an add-on from CRTech
- CR Tech TD Direct
  - Formerly known as CRTech Thermal Adaptor
  - Provides tools for marking up geometries (edges, faces, solids) prior to export and meshing in TD
  - Has a mesher, SCMesh, which overcomes many of TDMesh's shortcomings



## PROCESS OVERVIEW: OLD WAY...



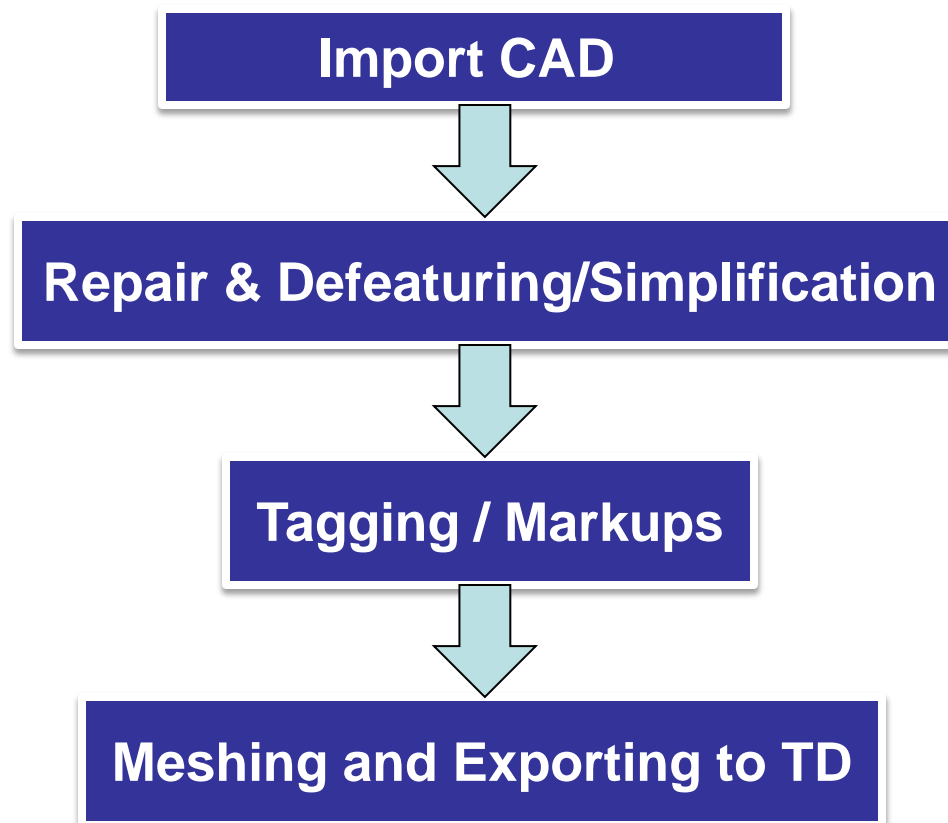
- Often the need exists to import CAD geometries generated in different software packages. Problems include:
  - Can't open (don't have software, AutoCAD/TD can't open)
  - Includes many thermally irrelevant details
  - Out-of-date version of CAD design
  - Thermal analyst unfamiliar with native software
- CAD used for:
  - Info/data to generate scratch-built TD model
  - Import into AutoCAD/TD for:
    - Use as scaffolding
    - Using TD Mesh to directly mesh the imported geometry
- Imported CAD typically requires defeaturing/simplification before use w/TD Mesh



- SC/TD Direct:
  - Provides additional tools for:
    - Import
    - Repair, Defeaturing/Simplification
    - Generating/customizing FE meshes
- Based on author's experience - three major benefits:
  - Gains in speed/ease of import and preparation of geometry
  - Easier to maintain high geometric fidelity while maintaining control over total node/element count
  - Ability to update meshes without losing and then having to redefine network elements (e.g. heat loads, contactors)



# PROCESS OVERVIEW: NEW WAY...





# IMPORTING



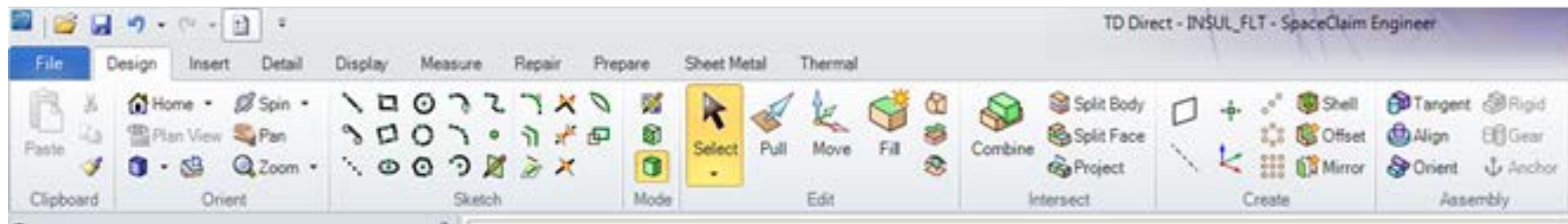
- SC can import/export ~ two dozen different formats
  - May require acquiring one of two additional “data exchange” plug-ins
  - Some formats:
    - Pro/E
    - SketchUp
    - STEP, ACIS, Parasolid, IGES
    - Solidworks
    - CATIA
    - NX
- SC provides options for automatically repairing geometry to allow defeaturing/simplification/meshing



# REPAIR & DEFEATURING/SIMPLIFICATION



- Simplified with use of a direct modeler like SC
  - Can modify features directly, unlike parametric modelers (e.g. Pro/E) which has history-based dependencies
  - Highly intuitive use – no need for extensive training to be effective



- In author's experience, many modifications could be made with use of pull tool alone

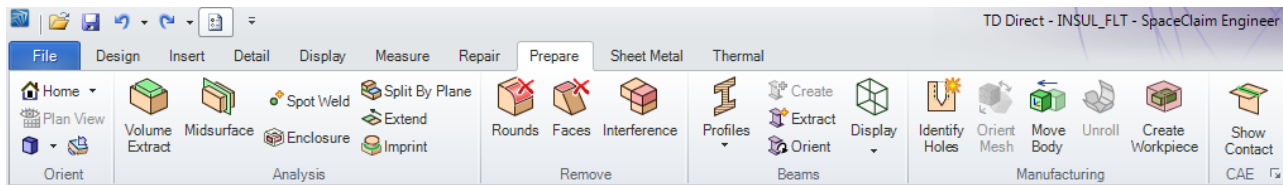
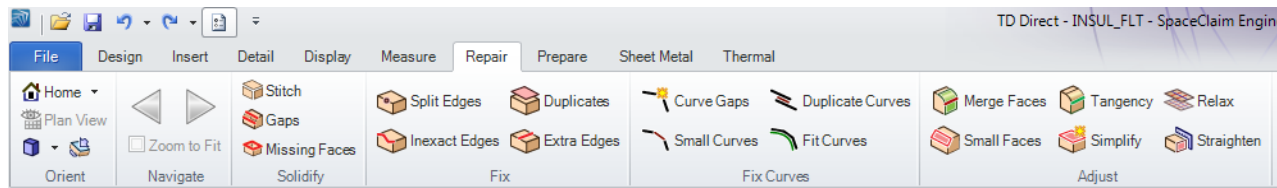
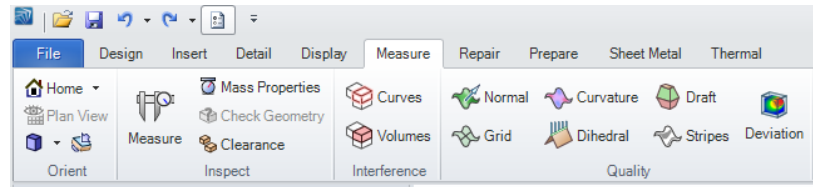




# REPAIR & DEFEATURING/SIMPLIFICATION



- Other tools available for repair of small edges, slivers, missing surfaces, overlaps in assemblies, and other issues that would cause mesher to fail





# TAGGING



- Tools for this are part of TD Direct
- Allows info to be added to features of geometry for:
  - Use by TD
  - Use by SCMesh during export to TD
- **Tags include**
  - Submodel names
  - Domains
  - Thermophysical & optical property name (or alias)
  - Radiation Analysis Groups
  - Thicknesses (of a surface)
  - Orienters
  - Mesh Controls



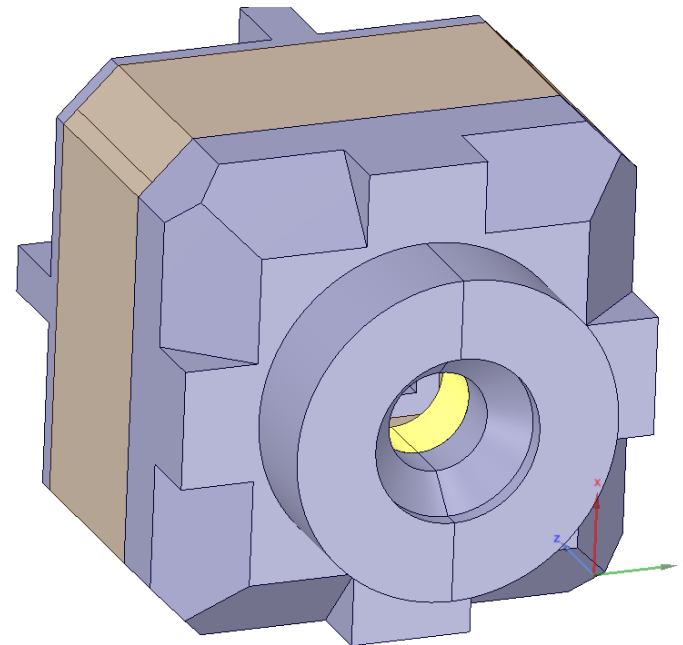
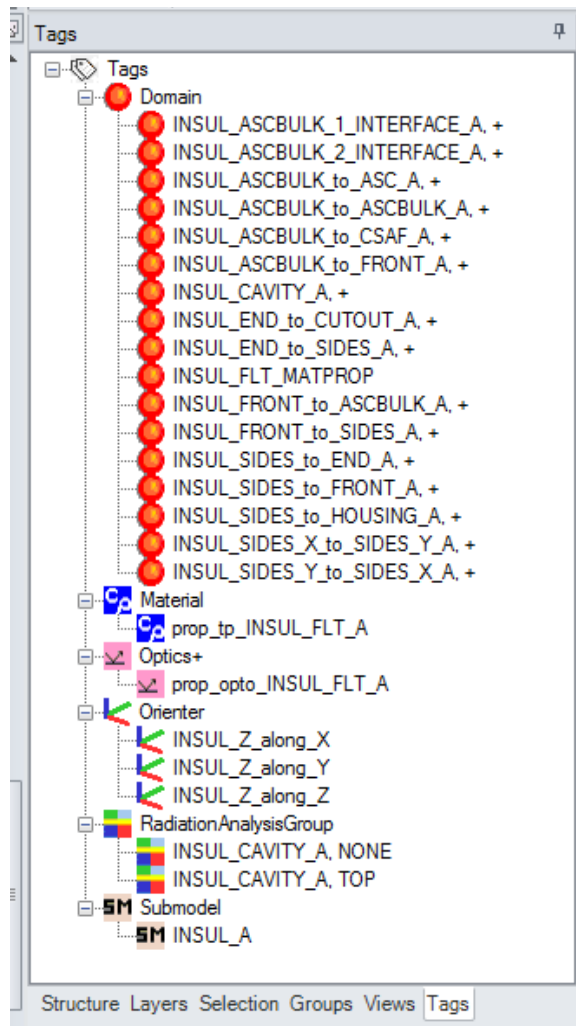
# TAGGING



- Tags further differentiated into two categories:
  - Thermal
    - Surfaces
    - Solids
    - Individual faces of solids
  - Mesh
- Thermal Tags are carried over to TD
- ‘Special’ Thermal Tag – Domain Tags
  - Applied to collection edges, faces, surfaces, solids
  - Utility example: TO and FROM surfaces in network object
- Tags can be modified in SC and will automatically be updated in TD by re-synching the SC file w/ TD



# TAGGING





- Mesh Tags/Controls
  - Global
    - Mesh Size (absolute or relative)
    - Mesh Size Scaling (X, Y, and Z directions)
    - Surface Mesh Type (Triangular or Quad Dominant)
    - Curvature Refinement & Lower Limits on Mesh Size of the Curve (absolute or relative)
    - Ignore Small Features and Max Number of Nodes
    - Mesh type for contacting Geometry (merged, independent, and matched)
  - Local
    - Surface Mesh Type (quadrilateral)
    - Swept Mesh
    - Merge if imprinted (for contacting geometries)



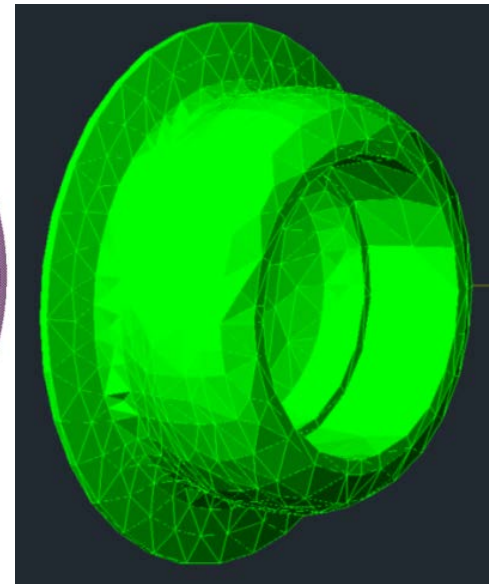
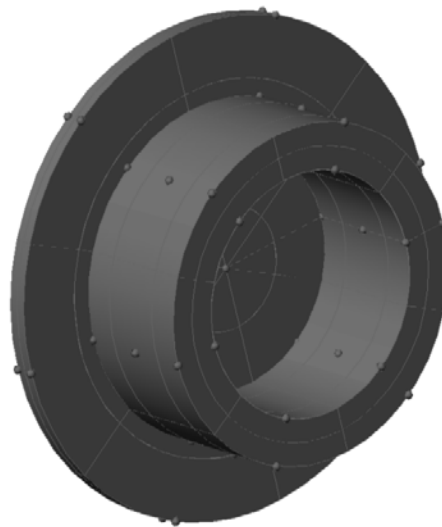
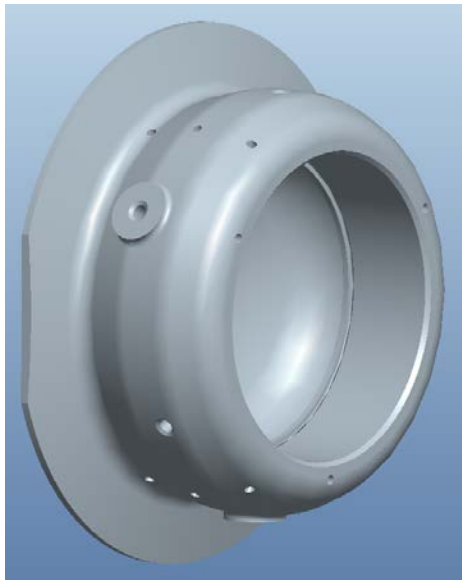
- TD Direct Importer created in TD
  - TD Pull-Down Menu: *TD Direct>Create Link*
  - User specifies geometry of interest (SC file path)
  - TD model can have multiple importers for multiple instances of same geometry OR for completely different geometries
  - Once created, remains as a dynamic link between SC and TD. Future changes made in SC will be updated in TD when importer is re-synched
  - Geometry/Mesh can be repositioned by moving just the importer (note...the importer appears as a 'bounding box' with an identifying tag)
  - Layers are created for 2D elements , 3D elements, and the mesh controller. An additional layer is created if the geometry is imported (not necessary)



# ASRG Example



- Heat Collector



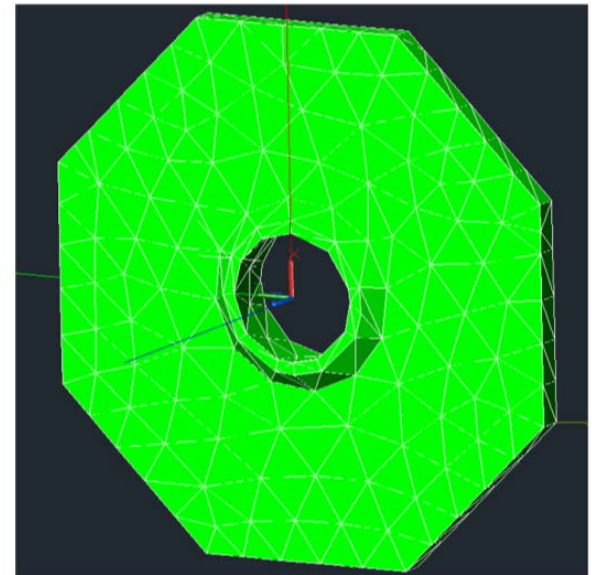
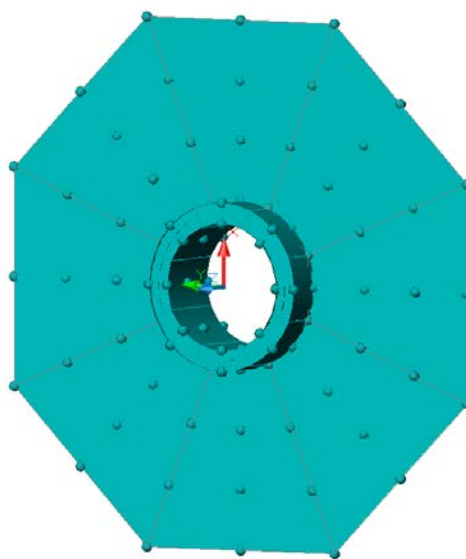
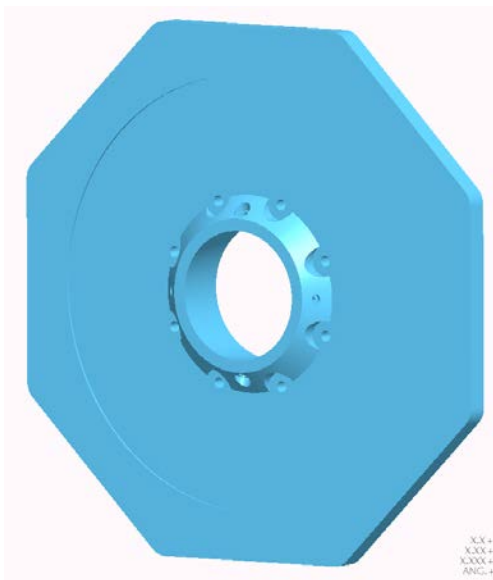




# ASRG Example



- CSAF

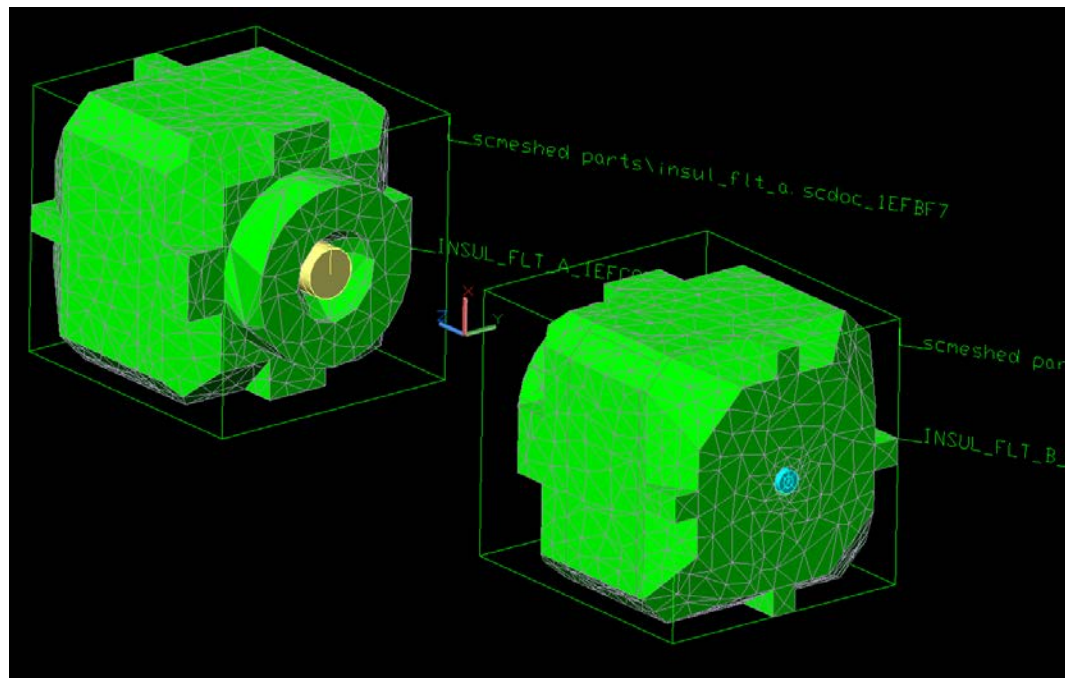
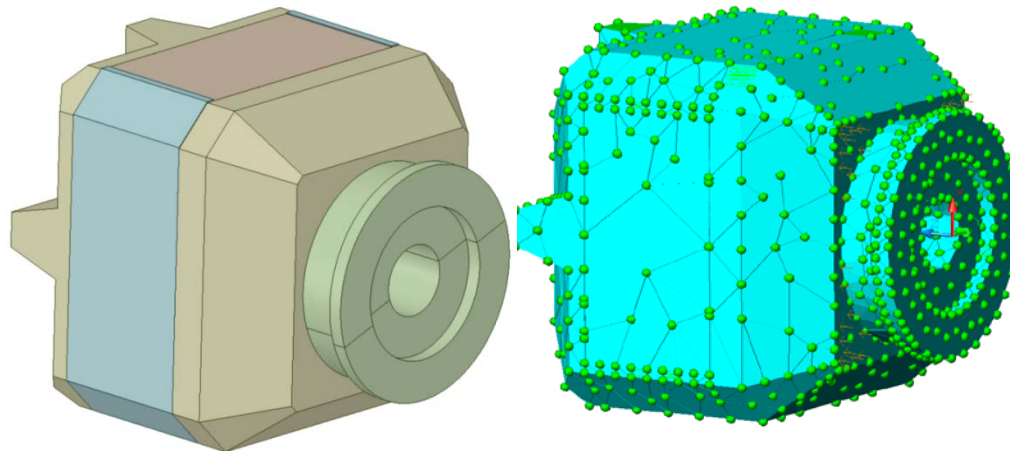




# ASRG Example



- Insulation Block

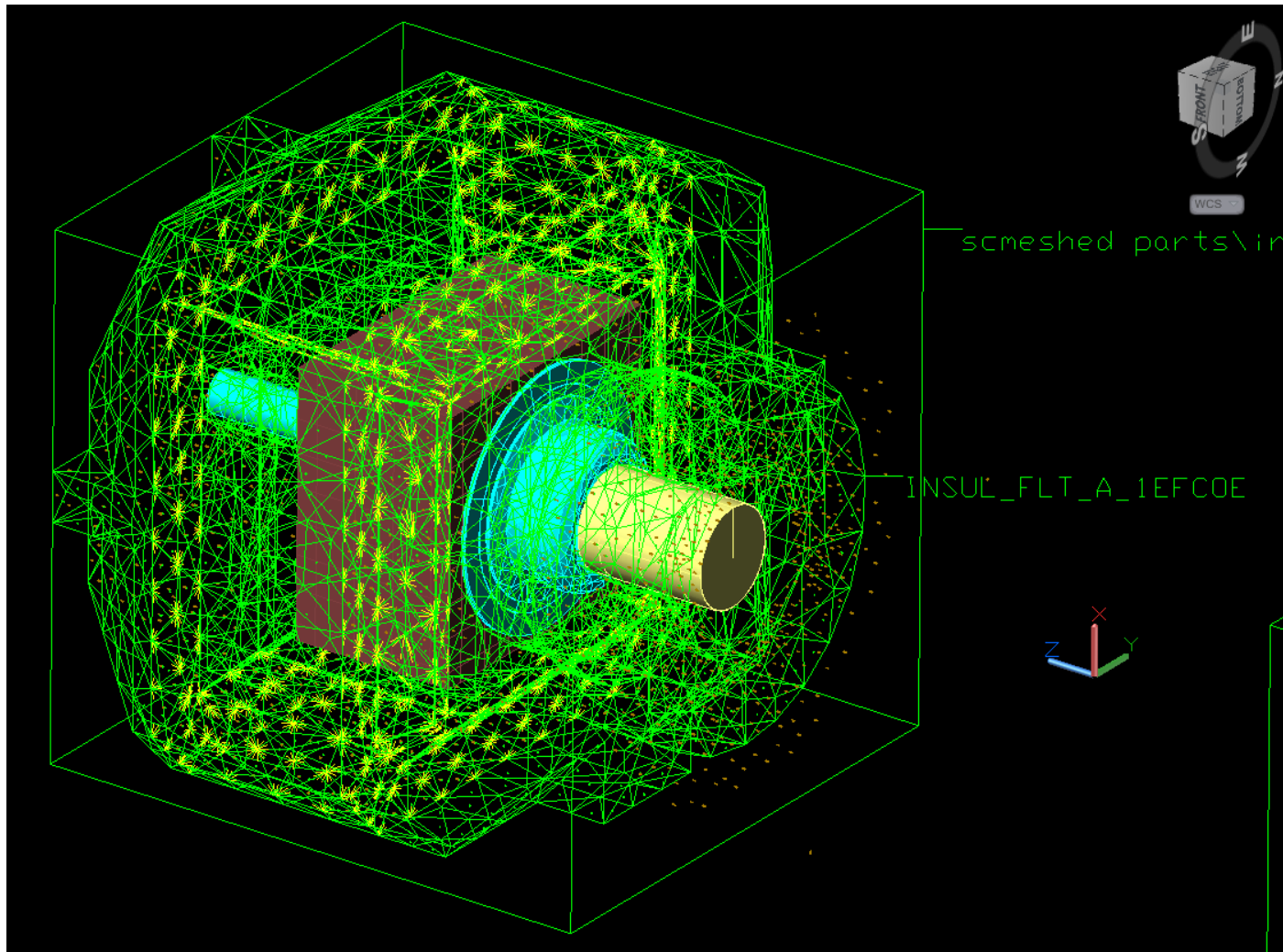




# ASRG Example



- Tagging Example: Contactors





# Best Practices Lessons Learned



- Use the SC Basic & Intermediate Tutorials.
- Stay organized. Create sensible file/part/assembly naming scheme.
- Learn how SC documents handle dependency, how to internalize or make external.
- Use folder at same level as .dwg file for keeping SC files for that TD model. Avoid path issues if relocated. (Don't want to have to recreate an importer from scratch).
- Create practice models with the essential features to vet your approach before attacking complex geometries or assemblies. Also easy to share with tech support.
- Use CRTech support – Use Support forums. Help build a resource for the community by asking questions there.
- Use SC for new geometry creation.
- Learn the lingo – reduce the challenges of learning a new software tool – helps understand new ways of doing things.
- Share what you learn – use your work as an example. Lots of ways to do the same thing – use what works best for your situation. It's just a tool.



# Summary



- Gains of SC/TD Direct:
  - Work faster/easier.
  - Additional tools for import, defeaturing/simplification, and meshing.
- Good for maintain high geometric fidelity directly from CAD. (Allows easy generation of complex geometries from scratch).
- As always, up to analysts to make choices.
  - Understand limits of tools
  - Understand needs of analysis
- The accompanying paper is not an extensive review of the capabilities of these tools. Many more features – and many more being added. This was a first attempt – would likely do things different.
- Adds needed capabilities to TD (and SINDA/FLUINT) modeling environment.
- Anyone who uses TD would benefit from familiarizing themselves with these tools and their capabilities – use them when it makes sense and makes your life easier!



# Back Up: References



1. Chan, Jack, J. Gary Wood and Jeffrey G. Schreiber. Development of Advanced Stirling Radioisotope Generator for Space Exploration. NASA/TM-2007-214806. Cleveland, OH: NASA Glenn Research Center, 2007.
2. Cullimore and Ring Technologies. Thermal Desktop User's Manual. Version 5.6. 2013.
3. Cullimore and Ring Technologies. Thermal Desktop Advanced Modeling Guide. Version 5.6. 2013.
4. Cullimore and Ring Technologies. CRTech TD Direct User's Guide. Version 5.6. 2013.